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Incidence of Postoperative Hematomas Requiring Surgical Treatment in Neurosurgery: A Retrospective Observational Study

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■ **OBJECTIVE:** We aimed to characterize the occurrence of postoperative hematoma (POH) after neurosurgery overall and according to procedure type and describe the prevalence of possible confounders.

■ **METHODS:** Patient data between 2010 and 2012 at the Department of Neurosurgery in Helsinki University Hospital were retrospectively analyzed. A data search was performed according to the type of surgery including craniotomies; shunt procedures, spine surgery, and spinal cord stimulator implantation. We analyzed basic preoperative characteristics, as well as data about the initial intervention, perioperative period, revision operation and neurologic recovery (after craniotomy only).

■ **RESULTS:** The overall incidence of POH requiring reoperation was 0.6% ($n = 56/8783$) to 0.6% ($n = 26/4726$) after craniotomy, 0% ($n = 0/928$) after shunting procedure, 1.1% ($n = 30/2870$) after spine surgery, and 0% ($n = 0/259$) after implantation of a spinal cord stimulator. Craniotomy types with higher POH incidence were decompressive craniectomy (7.9%, $n = 7/89$), cranioplasty (3.6%, $n = 4/112$), bypass surgery (1.7%, $n = 1/60$), and epidural hematoma evacuation (1.6%, $n = 1/64$). After spinal surgery, POH was observed in 1.1% of cervical and 2.1% of thoracolumbar operations, whereas 46.7% were multilevel procedures. 64.3% of patients with POH and 84.6% of patients undergoing craniotomy had postoperative hypertension (systolic blood pressure >160 mm Hg or lower if indicated). Poor

outcome (Glasgow Outcome Scale score 1–3), whereas death at 6 months after craniotomy was detected in 40.9% and 21.7%, respectively, of patients with POH who underwent craniotomy.

■ **CONCLUSIONS:** POH after neurosurgery was rare in this series but was associated with poor outcome. Identification of risk factors of bleeding, and avoiding them, if possible, might decrease the incidence of POH.

INTRODUCTION

In neurosurgery, postoperative hematoma (POH) is a rare, but serious, complication that frequently leads to severe neurologic impairment or death.^{1–3} POH rates after intracranial procedures vary greatly, mainly because of the differences in defining POH.² It is not always possible to distinguish between expected residual blood and small de novo hemorrhages, and therefore, it has been concurred that the best definition for a significant postoperative intracranial hemorrhage is a hematoma clinically requiring surgical evacuation.²

Although some studies have reported POH after even up to 50% of craniotomies in certain subgroups and based on routine radiologic monitoring,^{2,4–6} the overall incidence of clinically deteriorating POH range from 0.48% to 7.1%.^{1,2,7–21} In spinal surgery, the incidence of epidural POH requiring surgical evacuation is reportedly 0.1%–3%.^{3,22–34}

Key words

- Delayed postoperative spinal epidural hematoma
- Neurosurgery
- POH
- Postoperative hematoma
- SEH
- Spinal epidural hematoma
- Spinal surgery

Abbreviations and Acronyms

- AVM:** Arteriovenous malformation
- DPOSEH:** Delayed postoperative spinal epidural hematoma
- DVT:** Deep vein thrombosis
- ICU:** Intensive care unit

POH: Postoperative hematoma

VTE: Venous thromboembolism

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Because POH rates after neurosurgery vary greatly, the purpose of this study was to determine the incidence of POH overall in neurosurgery and according to procedure type. In addition, we aimed to describe the prevalence of previously described possible risk factors^{1-7,9-18,22-30,35-37} for developing a perioperative bleeding complication in neurosurgery.

METHODS

Data Collection

This was a retrospective observational study. All neurosurgical patients at the Department of Neurosurgery in Helsinki University Hospital, Helsinki, Finland with POH requiring surgical removal between January 2010 and December 2012 were initially included in the study. Patients were identified simultaneously by our electronic database and logbook with primary procedure code defined as “postoperative hematoma.” Every patient’s electronic, as well as paper, medical record was analyzed regarding preexisting comorbidities, presence of previous surgeries on spine, preoperative and perioperative medication, initial intervention, perioperative period, revision operation, and neurologic recovery (this last factor after craniotomy only). All cases that were incorrectly coded in the electronic database or that showed an extracranial or no hematoma during reoperation were excluded from final analysis.

Postoperative Care in the Study Center

All patients after craniotomies and cervical intradural spinal procedures are admitted to the neurosurgical intensive care unit (ICU) until the first postoperative day (e.g., up to 24 hours). Patients after spinal surgery are generally monitored for 2–6 hours also in the same department. Postoperative imaging (computed tomography or magnetic resonance imaging) is performed in selective cases according to the surgeon’s decision and patients’ clinical status. Local protocol on deep vein thrombosis (DVT) chemoprophylaxis is conservative. Mechanical prophylaxis (compression stockings or intermittent pneumatic compression devices) is used in all patients at risk for DVT. Pharmacologic prophylaxis with low-molecular-weight heparin is started in high-risk patients within 5–7 days postoperatively but usually not earlier than 3 days after surgery. In complex cases, an individualized multidisciplinary approach, including an anesthesiologist, neurosurgeon, and thrombosis specialist, is implemented.

Data Analysis

Data are given as mean with standard deviation and range. Descriptive statistics were evaluated with Microsoft Excel, version 14.4.7 (Microsoft Corporation).

RESULTS

Incidence of POH

During the 3-year period, 8783 procedures were performed, including 4726 craniotomies, 2870 spinal surgeries, 928 shunting procedures, and 259 implantations of spinal cord stimulators and drug pumps. In 0.6% of procedures (56 cases of 8783: 26 after craniotomies and 30 after spine operations), 53 patients had POH leading to surgical removal. Four patients with POH after craniotomy (17.4%) and one after spinal procedure (3.3%) had POH

more than once, whereas 1 patient with serious traumatic brain injury had 4 different procedures initially (decompressive hemi-craniectomy on both sides that was later followed by cranioplasty to both sides), after which POH developed every time. Thus, the overall incidence of POH after craniotomies and spinal surgery was 0.6% and 1.1%, respectively.

Baseline Characteristics

Patients’ general data are summarized in **Table 1**. Patients had an average age of 60 years (range, 20–88) and 50.9% of patients were male. The most common underlying diseases were hypertension and diabetes, whereas about one third of patients for spinal procedure had previously had an operation on the same part of the spine.

Risk Factors

Of the possible risk factors described in earlier studies,^{1-7,9-18,22-30,35-37} medications that have been reported to interfere with coagulation cascade (nonsteroidal antiinflammatory drugs, antiplatelet drugs, anticoagulants, selective serotonin reuptake inhibitors, and antiepilepsy drugs) were being used preoperatively or postoperatively in 66.1% of cases, although in elective cases (69.6%), they were discontinued before the primary intervention according to our institutional recommendations. Hypertension (systolic blood pressure >160 mm Hg or lower if indicated) during the early postoperative period was present in 64.3% of all cases, whereas after craniotomies the rate was even higher (84.6%). Of patients with postoperative hypertension who underwent craniotomy, 81.8% received antihypertensive medications (labetalol, clonidine, or other) in the ICU. The incidence of laboratory disturbances possibly leading to hemorrhagic complications

Table 1. Baseline Characteristics

	Craniotomies	Spinal Surgery	All Together
Demographics			
Male gender	10 (43.5)	17 (56.7)	27 (50.9)
Age (years), mean \pm standard deviation	56 \pm 20.8	63 \pm 12.4	60 \pm 17.0
Body mass index (kg/cm ²), mean \pm standard deviation	25.7 \pm 4.2	27.4 \pm 4.0	26.6 \pm 4.2
Underlying diseases			
Ischemic heart disease	2 (8.7)	3 (9.4)	5 (9.4)
Hypertension	9 (39.1)	14 (46.7)	23 (43.4)
Diabetes	3 (13.0)	5 (16.7)	8 (15.1)
Renal insufficiency	1 (4.3)	3 (9.4)	4 (7.5)
Liver insufficiency	0 (0)	1 (3.1)	1 (1.9)
Previous surgery	NR	8 (26.7)	NR
Emergency admission	13 (50.0)	4 (13.3)	17 (30.4)
Values are number (%) except where indicated otherwise. NR, not reported.			

(hemoglobin <100 g/L, platelet count <100 × 10⁹/L, prothrombin time value <70% (normal laboratory reference range, 70%–120%) or any other coagulational defect) before the primary or hematoma evacuation procedure was relatively low (14.5%, 17.3%, and 15.1%, respectively), as well as perioperative hypothermia (body temperature <35°C) during the initial intervention (25.0%).

Data from Index Procedure

Mean American Society of Anesthesiologists score before primary procedure was 3, whereas it was ≥4 in 53.8% of craniotomies and in 6.7% of spinal procedures. Emergency or urgent surgery was primarily performed in 30.4% of all cases and 50.0% of craniotomies. In craniotomies (see Table 2), the procedure types with highest POH incidence were decompressive craniectomy, with a rate of 7.9% of cases (7 of 89); cranioplasty, with 3.6% (4 of 112); bypass surgery with 1.7% (1 of 60); and epidural hematoma removal, with 1.6% (1 of 64). No POH was reported after elective aneurysm, arteriovenous malformation (AVM), dural fistula, intracerebral hemorrhage removal, shunting procedures, or epilepsy surgery during the study period. Of brain tumors, 60% (6 of 10) were extirpated and 40% (4 of 10) were partially resected.

In spinal surgery, POH occurred after 0.4% of cervical (6 of 1455) and 2.1% of thoracolumbar (24 of 1143) operations. Of spinal surgeries, 46.7% were multilevel procedures. All lesions were intradural.

Table 2. Intracranial Surgical Procedures and Development of Postoperative Intracranial Hematoma

Surgical Procedure	Procedures (n)	Hematomas (n)	Incidence (%)
Tumor surgery	1495	10	0.7
Aneurysm surgery	784	1	0.1
Nonruptured	419	0	0
Ruptured	365	1	0.3
Arteriovenous malformation surgery	73	0	0
Dural fistula surgery	13	0	0
Hematoma removal	1378	3	0.2
Subdural, acute	322	1	0.3
Subdural, chronic	803	1	0.1
Epidural	64	1	1.6
Intracerebral	189	0	0
Epilepsy surgery	127	0	0
Craniectomy	89	7	7.9
Cranioplasty	112	4	3.6
Bypass surgery	60	1	1.7
Other	595	0	0
Total	4726	26	0.6

Mean blood loss during craniotomies was 603 ± 163 mL (range, 0–4000 mL) and during spinal procedures 192 ± 65 mL (range, 0–1400 mL), whereas 42.3% of patients undergoing craniotomy received red blood cell transfusion during index procedure.

Data from Hematoma Evacuation Procedure

Most POH evacuations were performed because of clinical deterioration, although there were also a few POH that were detected by radiologic imaging but because of large size or critical localization were evacuated based on the surgeon's decision.

In spinal surgery, the localization of POH was epidural in most cases (93.3%), whereas in craniotomies, it was epidural in 43.3%, subdural in 20.0%, intracerebral in 16.7%, and mixed in 20.0% of cases. After tumor surgery (total number 10), 50% were intraparenchymal, 20% epidural, 20% subdural, and 10% were mixed hematomas. After craniectomies (total number 7), 71% were epidural, 14% subdural, and 14% in mixed localizations. All hematomas after cranioplasties (total number 4) were epidural.

Hematoma evacuation was performed between 0 hours (when noticed immediately in the theater) and 20 days after the initial operation, whereas the average time until reoperation after craniotomies was 2.7 and 3.7 days after spine procedures. POH was recognized and treated within 24 hours in 42.3% of cases after craniotomies and in 26.6% after spinal procedures, whereas 53.3% of spinal hematoma evacuation surgeries were performed more than 3 days after the index procedure, so the incidence of delayed postoperative spinal epidural hematoma (DPOSEH) in our series was 0.6% (16 of 2870). The longest duration until recognition of spinal POH and hematoma removal was 11 and 13 days, respectively.

Outcome and Thrombotic Complications

Poor outcome (evaluated by Glasgow Outcome Scale score 1–3) and death (Glasgow Outcome Scale score 1) at 6 months follow-up period were detected, respectively, in 40.9% and 21.7% of patients with POH after craniotomy. Because proper evaluation of clinical outcome after spinal procedure retrospectively, based on medical records, was problematic, we do not report it in this study.

One lower-extremity DVT, 1 thrombosis of the internal jugular vein and venous sinuses, and 1 pulmonary embolism were detected in this group of patients. The overall incidence of thromboembolic complications in neurosurgical patients with POH was therefore 5.7%, and because all 3 cases were after craniotomies, the incidence in this subgroup was even higher (13.0%).

DISCUSSION

POH after neurosurgery requiring surgical evacuation was an uncommon complication in this series, occurring at an overall rate of 0.6% (0.6% after craniotomies and 1.1% after spinal procedures). There are not many systematic data about the overall rates of POH after craniotomies; incidence figures vary depending on definition, with rates of 0.48%–7.1% reported for postoperative clinical deterioration after surgical evacuation^{1,2,7–21}; and 10.8%–50.0% based on routine radiologic monitoring, according to a systematic review published in 2011.² The investigators in that particular review also included recommendations for clinical

practice based on the literature reviewed² and most of those already formed part of the daily practice and treatment protocols of our neurosurgical unit. This factor certainly contributes to the relatively low occurrence of POH after craniotomies in this series compared with the average rates published in the literature so far. Also, there might have been a few patients with clinically important POH after craniotomies who nevertheless did not undergo reoperation, but because of the retrospective design of the study, we were unable to detect those patients and therefore they might not have been included in the analysis.

A systematic review of symptomatic epidural POH after spine surgery³ found an overall calculated incidence of 0.2%, with individual study incidence ranging from 0% to 1.0%. So, the occurrence of 1.1% in the current series was slightly higher than the reported overall calculated incidence. This difference might be because 2 patients with POH in the soft tissues that nevertheless caused clinical deterioration were included in the analysis. POH after spinal surgery usually presents early in the postoperative period, but DPOSEH can be the cause of neurologic deterioration after spinal surgery (symptoms appear >3 days after the index procedure).²⁴ So far, the incidence of DPOSEH has been reported to vary between 0.05% and 0.17%^{24,26,28} and the longest duration until symptom onset has been 13 days after the initial surgery.²⁷ In our series, we detected a surprisingly high incidence of DPOSEH (0.6%), whereas the longest duration until recognition of POH and hematoma removal was 11 and 13 days, respectively. So, this relatively higher frequency of DPOSEH might also play a role in the greater overall incidence of POH after spinal surgery in this series.

Rapid diagnosis of POH and earlier surgical intervention may result in greater neurologic recovery.^{22,28,30} POH was recognized and treated within 24 hours after 42.3% of craniotomies and 26.6% of spinal procedures in this series. Previously, it has been suggested that patients having elective supratentorial operations can safely be transferred from the ICU to a neurosurgical ward for observation, if they have regained their preoperative neurologic status by 6 hours after surgery.⁸ Another older study showed no clear relationship between the time of recognition of POH after spinal surgery and the final clinical outcome,⁷ but newer studies are needed to reevaluate the importance of POH onset on prognosis.

POH Incidence After Different Types of Procedure

Our observations may indicate that POH is more often seen after decompressive craniectomy, cranioplasty, bypass surgery, and epidural hematoma removal. A recent retrospective multicenter study also showed that primary craniotomy for hematoma evacuation is associated with higher risk for rebleeding postoperatively.¹⁸ In addition, according to the systematic review published in 2011 and mentioned earlier, traumatic lesions are intracranial diseases more prone to POH.² In older studies, POH was described after 3.7%–6.9% of craniotomies for traumatic intracranial mass.⁴ Decompressive craniectomy, cranioplasty, and epidural hematoma removal can all be partly related to traumatic brain injury, and therefore, our findings support the data on traumatic lesions reported so far. Concerning craniectomies in this series, all patients had developed malignant intracranial hypertension: 1 patient underwent the

procedure because of cerebellar infarction, 1 because of internal carotid artery aneurysm rupture, and the remaining 5 patients all had traumatic injuries. Decompressive craniectomy carries a significant risk of rebleeding postoperatively (usually contralateral to the craniectomy site) and our findings (incidence of 7.9%) support the data reported so far.^{38–42} The relatively high incidence of POH (3.6%) after cranioplasty in this series is also in line with the rates from the literature; POH as a complication occurs after up to 6.9% of cranioplasties.^{43–49} Regarding bypass surgery, it has also been reported previously that ICH after vascular reconstruction surgery (as a result of moyamoya disease) occurs in 2.8% of cases,⁵⁰ which is comparable to the detected rate of 1.7% in our series.

In contrast to concurring findings on traumatic lesions and bypass surgery, there were no POH after AVM removals in the present series, indicating that AVM by pathology itself might not be prone to bleeding complication. A systematic review and meta-analysis on AVMs has reported an overall POH rate of 1.4 per 100 person-years.⁵¹ According to that review, POH is uncommon after microsurgical removal of AVMs (0.18 per 100 person-years). All AVM removals are performed microsurgically in our institution, and therefore, this technique might be 1 key component in decreasing the risks of POH after AVM removal. Our observations in neoplasm surgery differ also from previous findings. So far, overall rates of POH after neoplasm surgery have ranged from 1.1% to 7.1%,^{1,5,8,52–56} which is higher than the rate detected in this series (0.7%).

The incidence of POH after elective aneurysm surgery varies between 0.1% and 2.6%.^{1,57–61} In our series, there was no POH after elective aneurysm surgery and the reason for such a low rate might be that in our center, elective aneurysm clippings were performed mainly by 1 highly experienced senior surgeon micro-neurosurgically. Although according to an older study,⁸ there was no correlation between the rank of the surgeon and the occurrence of POH after craniotomy, in a newer study, there was a lower rate of surgical complications (15.8% vs. 28.6%) and surgical vascular complications (7.6% vs. 16.7%) among high-volume (clipped >40 aneurysms per annum during the study period) compared with low-volume surgeons (<40 aneurysms), but this was statistically not significant.⁶² However, patients operated on by high-volume surgeons were significantly less likely to have a new neurologic deficit on discharge (17.1% vs. 33.3%; $P = 0.03$), so experience may play a role in such a low incidence of POH after unruptured aneurysm clippings in this series.

POH Risk Factors

Earlier studies of POH after craniotomy have suggested an association with advanced age, preexisting, intraoperative, and postoperative hypertension, coagulopathies (also caused by preoperative medications), great intraoperative blood loss, blood transfusion during or after the index operation, primary craniotomy for hematoma evacuation, specific types of tumors, and postoperative ventilator dependence >48 hours as well as unplanned reintubation.^{1,2,4,7,9–18,35,36} Although risk factors for identifying patients at high risk of developing spinal epidural POH have been suggested, because of the rare occurrence of this complication, there are limited and inconsistent data about risk factors for POH in spinal surgery. However, a multicenter case

control study³⁰ has identified that alcohol consumption greater than 10 units a week, multilevel procedure, and previous spinal surgery are all associated with developing POH after spine surgery. Of previously detected risk factors, hypertension (preexisting, intraoperative, and postoperative) had the highest occurrence in this sample. Although all our patients undergoing craniotomy are kept until at least the next morning in the ICU, where blood pressure is monitored routinely and a goal blood pressure is set (160 mm Hg or lower, if indicated), a relatively high percentage of patients (84.6%) presented with postoperative hypertension after craniotomy, whereas not all of them received antihypertensive medications in the ICU. On one hand, this factor might support the previous findings about possible risk factors,^{10,16,18} but on the other hand, we registered any increase (except artifacts) in systolic blood pressure greater than 160 mm Hg postoperatively, so this finding might also be aggravated by our method. Further studies are needed to assess whether even a short-term increase in systolic blood pressure, which disappears spontaneously, should be aggressively treated and what should be the exact target blood pressure to avoid bleeding complications. However, special attention should be paid to optimizing the patient's antihypertensive treatment preoperatively and pain treatment postoperatively to keep the patient normotensive.

Outcome and Complications After POH

The overall incidence of venous thromboembolism (VTE) in patients undergoing craniotomy is 2.6%–3.5%,^{17,63–66} whereas in neoplasm neurosurgery, the rates are remarkably higher, ranging from 3% to 26%, even with DVT prophylaxis.^{55,56,67} In the current series, the occurrence of VTE in neurosurgical patients with POH was 5.7%, and in postcraniotomy patients with POH, it was 13.0%. So far, there have been only a few data about neurosurgical patients who have hemorrhagic and thromboembolic complications at the same time.⁶⁵ Our findings show the heterogeneity and complexity of neurosurgical patients prone to POH, albeit they are

at risk of developing bleeding complications, they seem to be predisposed to VTE. One possible explanation could be that clinically significant POH leads to reoperation and often also to prolonged ventilator dependence with bed rest, which all independently are well-known VTE risk factors.^{56,63,64,67,68} It is therefore challenging to start DVT prophylaxis in postcraniotomy patients with a bleeding complication, but on the other hand, in patients with a high risk for thrombosis, DVT prophylaxis is nevertheless indicated, even if they have high bleeding risk or have had a hemorrhagic complication. An individualized multidisciplinary approach in these patients might be the key component in balancing the risks of bleeding and thrombosis.

The main limitation of this study is its retrospective design and the rare occurrence of this complication. The results of a single-center study also partly lack generalizability. Moreover, we cannot suggest any definitive confounding factor, because this study did not include comparison with a control population. Therefore, we report only the cases that have been identified so far, and the results should be interpreted with caution because of low numbers of observed POH cases. Nevertheless, the findings of this study are valuable in providing patients with information regarding surgical risks and expected postsurgical management.

CONCLUSIONS

POH requiring surgical removal was a rare complication with an overall occurrence of 0.6% in this series (0.6% after craniotomies and 1.1% after spine operations). Our observations may indicate that POH is more often seen after decompressive craniectomy, cranioplasty, bypass surgery, and epidural hematoma removal. Elective aneurysm clipping, AVM removal, and epilepsy surgery can be performed with minimal bleeding complications. Because POH after craniotomy was related to high morbidity and mortality, proper identification of risk factors and avoiding them, if possible, might therefore decrease the incidence of POH and improve the outcome of these patients.

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